Radiative Processes in the 21 cm High Velocity Clouds Problem

John Barentine

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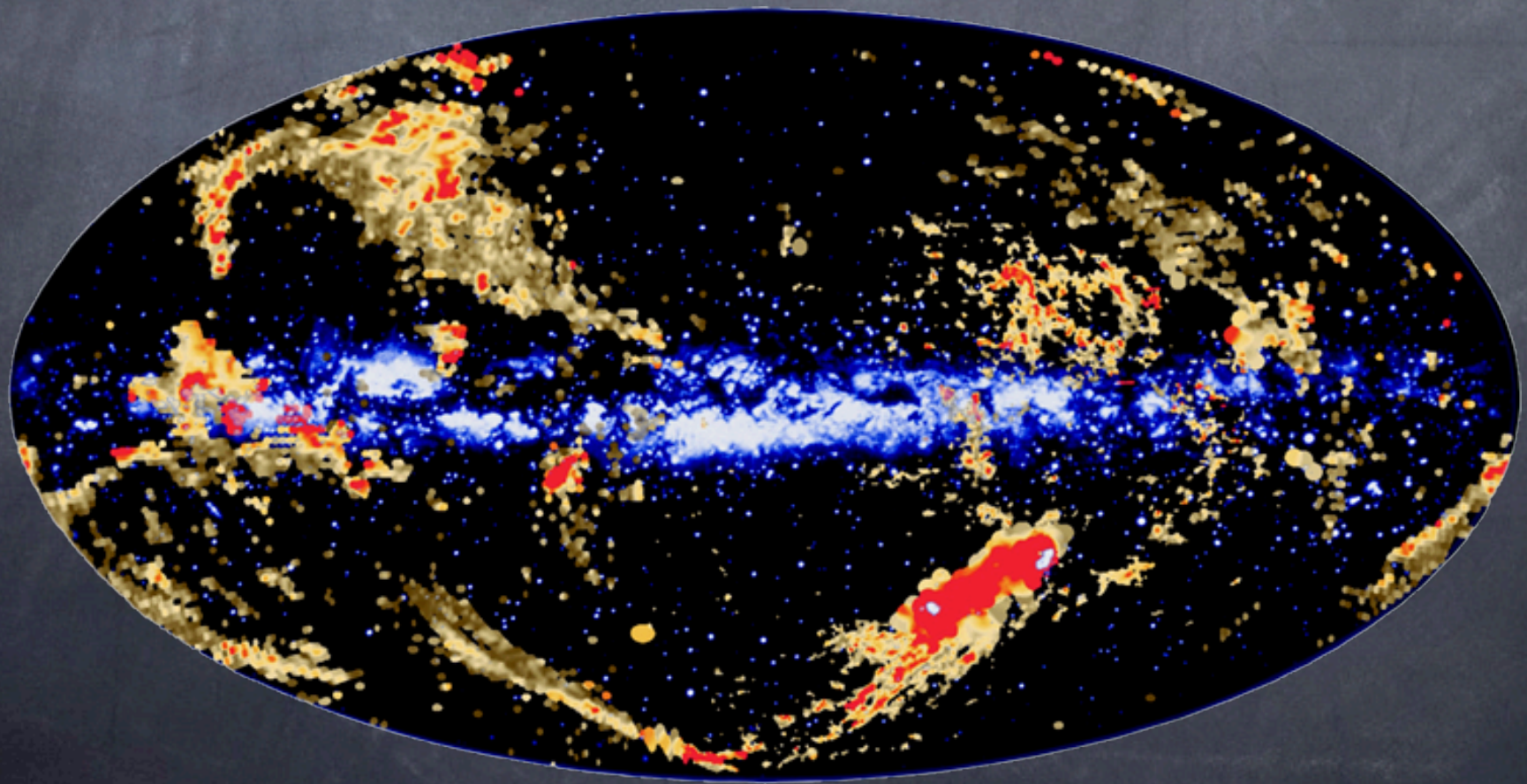
Talk Outline

- Phenomenology of the HVCs
- Radiative I. 21cm Line Emission
- Radiative II. Atomic Absorption

HVC Definition

"High-velocity clouds consist of neutral hydrogen moving at velocities incompatible with a simple model of galactic differential rotation."
(Wakker et al. 1999)



HVC Properties

Anomalous galactocentric velocities (± 50 km s^{-1})

Clear velocity separation from low-velocity gas

Generally high galactic latitude

Core-envelope structure

Little Ha emission; no CO

Low (0.1 solar) metallicity

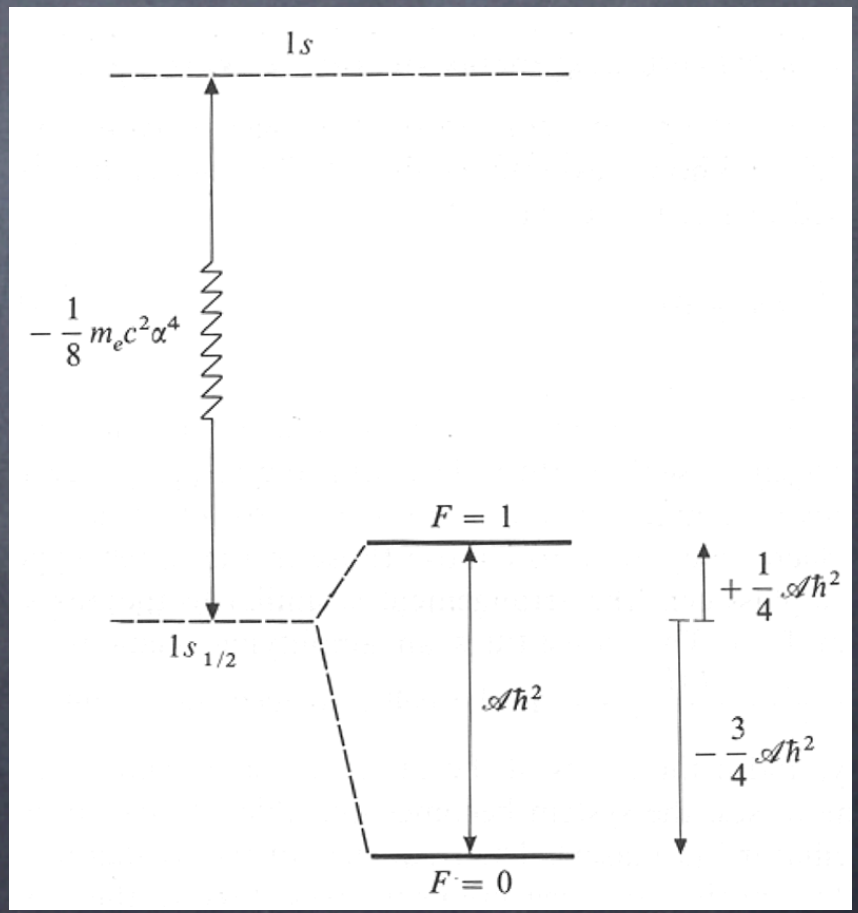
The 21cm Hyperfine Transition

Like a permanent Zeeman effect

$$H = -A\mu_e \cdot \mu_p$$

Splits 1s ground state

Forbidden in lab, but common in space



Radiative I. 21cm Emission

Common observable: Brightness Temperature

$$T_b = \frac{I_\nu c^2}{2k\nu^2}$$

Essentially pure absorption

$$dI_\nu = j_\nu ds$$

$$I_\nu(s) = I_\nu(s_0) + \int_{s_0}^{s} j_\nu(s')ds'$$

Relative populations give "spin temperature"

$$\frac{N_i}{N_j} = \frac{g_i}{g_j} exp\left(\frac{-hc}{\lambda_{ji}}\right).$$

$$\frac{hc}{\lambda_{ji}} = \frac{T_\star}{T_S}$$

Line profiles give column densities

$$N(HI) = \frac{32\pi k}{ch{\lambda_{ij}}^2 A_{ij}(g_i/g_j)} \frac{\sqrt{\pi}}{2\sqrt{\log 2}} T_S(\Delta\nu)\tau_0$$

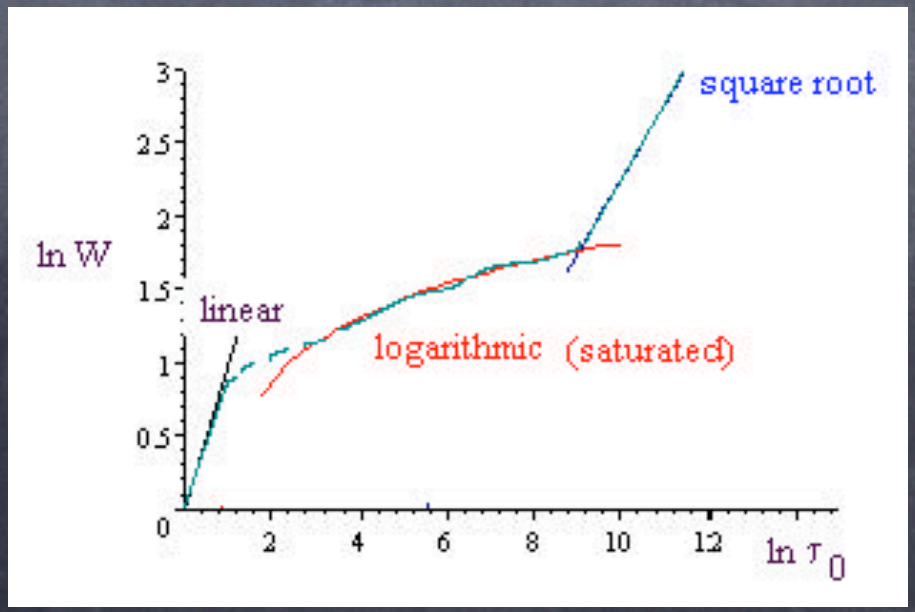
Radiative II. Atomic Absorption

Distance sources serve as "lightbulbs"

$$dI_\nu = -\alpha_{line,\nu} I_\nu ds$$

$$I_\nu(s) = I_\nu(s_0) exp\left[-\int_{s_0}^{s} \alpha_{line,\nu}(s')ds'\right]$$

Column densities obtained with curves-of-growth



Results From Application Of Radiative Transfer

H I Column Densities: 10^{17}-10^{18} cm^{-2}

(Wakker & van Woerden 1997)

"Metals" Column Densities: 10^{11}-10^{12} cm^{-2}

(Wakker & van Woerden 1997)

[Ca/H] ~ 0.04

[S/H] ~ 0.09

(Thom et al. 2006, Wakker et al. 1999)

Distances: few-tens kpc

(Wakker & van Woerden 1991)

References

Thom, C. et al. 2006 **ApJ** 638, L97

Wakker, B. et al. 1999 **Nature** 402, 388

Wakker, B., and van Woerden, H. 1991 **A&A** 250, 509

Wakker, B., and van Woerden, H. 1997 **ARA&A** 35, 217